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Group covariant channels and testing extremality

The most general form of evolution of a quantum state is described by a completely positive trace preserving (CPTP) map or a quantum channel.  The set of CPTP maps is convex and determining the extreme points of this set is of importance from different aspects. The first trivial advantage of having the extreme points is that a general CPTP map can be described as a convex combination of extreme points which leads to characterizing the set of channels. Apart from the role of extreme points in characterizing CPTP maps, they have application in other areas such as simulation of quantum channels. Explicit form of extreme points is known just for qubit channels and going beyond qubit channels is challenging. Despite all the efforts made, there is just partial success in understanding the properties of extreme points of qudit channel. Here, we determine a subset of extreme points of CPTP maps for qudit channels. Our strategy is to characterize the set of group covariant channels and then determine those group covariant channels which are extreme points. We develop an algorithmic approach with explicit pseudocode to construct group covariant channels for a given group (discrete finite groups or Lie groups) and testing whether they are extreme.